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Computer-Aided Systems Engineering for Flight Research Projects Using a Workgroup Database

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December 2004

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ABSTRACT

An online systems engineering tool for flight research projects has been developed through the use of a workgroup database. Capabilities are implemented for typical flight research systems engineering needs in document library, configuration control, hazard analysis, hardware database, requirements management, action item tracking, project team information, and technical performance metrics. Repetitive tasks are automated to reduce workload and errors. Current data and documents are instantly available online and can be worked on collaboratively. Existing forms and conventional processes are used, rather than inventing or changing processes to fit the tool. An integrated tool set offers advantages by automatically cross-referencing data, minimizing redundant data entry, and reducing the number of programs that must be learned. With a simplified approach, significant improvements are attained over existing capabilities for minimal cost. By using a workgroup-level database platform, personnel most directly involved in the project can develop, modify, and maintain the system, thereby saving time and money. As a pilot project, the system has been used to support an in-house flight experiment. Options are proposed for developing and deploying this type of tool on a more extensive basis.

NOMENCLATURE

CBE	current best estimate
CCB	configuration control board
CCR	configuration control request
CI	configuration item
DR	discrepancy report
D-REX	Ducted Rocket Experiment
eSE	Electronic Systems Engineering
GUI	graphical user interface
HR	hazard report
PFTF	Propulsion Flight Test Fixture
STR	system test report

INTRODUCTION

Systems engineering is defined as a robust approach to the design, creation, and operation of systems (ref. 1). Systems engineering is important for the successful execution of flight research projects, which characteristically have complex interdependencies between elements and subsystems. Typical systems engineering tasks in a flight research project include configuration control, document management, discrepancy tracking, hazard management, requirements management, verification and validation, action item tracking, and technical performance metrics.

Software tools often are used to facilitate systems engineering tasks, and these tools provide potential benefits. For example, current project data and documents can be instantly accessed online, and repetitive tasks can be automated, resulting in error reduction and improved situational awareness. A net savings of time and money could be realized, even considering the upfront investment to implement the software tools.

In flight research, however, each project is technically and programmatically unique, so a standard set of software tools is often unavailable or not applicable. If enterprise-level software packages were implemented, the life cycle cost for procurement, development, training, and administration would be high and burdensome for a relatively small organization like the NASA Dryden Flight Research Center (Edwards, California). Furthermore, NASA Dryden frequently is a partner in a project led by another organization, in which case the lead organization often mandates usage of its set of tools. NASA Dryden then becomes a client user of those software packages, which is the proper and economical approach, but any sizable investments in in-house tools are not recouped.

Most of these systems engineering tools are fundamentally databases. They generically store and organize information and present it in various ways. Many systems engineering tools are built on one of the well-known commercial or standard database applications.

Coincidentally, a commercial off-the-shelf workgroup database is already deployed center-wide at NASA Dryden (ref. 2). It is a relational database that is accessible over the network, scalable to over 100 users, and available for both PC and Mac platforms. As a workgroup-level tool, it can be programmed easily and quickly, allowing the people performing the work to develop the solution. The life cycle cost of solutions by means of this software is estimated to be one-fifth that of an enterprise-level database. In this case because the database is already procured and deployed, the cost savings may be even greater.

The implementation of an Electronic Systems Engineering (eSE) tool is proposed for in-house and NASA Dryden–led projects that use this platform database. Although this database is considered a workgroup-level tool, cases in which it has been used in some major aerospace applications are described on the vendor’s Web site. At NASA Dryden, it is used for work orders, aircraft scheduling, inspection, waivers, aircraft directives, operational training, flight logs, and flight project risk management. The database vendor's Web site indicates that the database has been used at some other major aerospace organizations for test tracking, maintenance documentation, parts tracking, document archiving, and instrument calibration data.

Figure 1 shows the overall setup of the eSE modules. An integrated set of modules is potentially more advantageous than separate products, because data are automatically cross-referenced between modules, and a common user interface and administration are possible. The project can still select the appropriate modules, depending on utility. Only the most expensive and complex enterprise-level products provide an integrated capability covering various systems engineering functions.

The eSE can be accessed online over the intranet from each user’s workstation. When a projector and networked computer are used during meetings or presentations, data can be displayed and collaboratively worked on in real time. Established institutional processes are implemented. Processes are owned by the current process owners, and are not changed to fit the tool. No redundant capability is generated for areas in which appropriate software tools already are available, such as finance, scheduling, project workflow, and work orders. A simplified approach is taken to provide maximum benefits for minimal cost. The system can be easily customized to meet unique project needs. The present capability of this tool is for nonsensitive in-house projects. Some essential features of the system are as follows:

- Online document viewing and editing capability
- User identification and password access control
- Privilege control based on user access level and document status
- Electronic signatures
- Electronic attachments
- Automatic summary data generation

Table 1 shows some of the benefits of using the eSE system.

Table 1. Benefits of using the eSE system.

Task	Old way	New way
Generate a hazard action matrix	Page through all the hazard reports and manually tally counts. Repeat periodically to keep current.	Push a button. Repeat to update.
View or submit configuration control forms	Walk to another building to view records or submit a hard copy. Data entry personnel enters data into system.	View, edit, and submit forms online.*
Obtain a project document	Ask author or someone else to E-mail the document and hope that it is the current version.	Download current document from server.
Track action items	Distribute a spreadsheet through E-mail. Manually incorporate inputs and updates	View and edit action items online.
Find hardware data	Search through large binders.	Navigate to data through links.
Generate a verification requirements matrix	Copy and paste requirements document text. Manually update if document changes.	Push a button. Updates are automatic.*

*Not used in pilot project.

Development of the eSE, including coding, debugging, testing and this documentation was accomplished in approximately 1000 person-hours. The eSE was demonstrated and further developed on a pilot project, the Ducted Rocket Experiment (D-REX), on the F-15B (McDonnell Douglas Corporation, St. Louis, Missouri) Propulsion Flight Test Fixture (PFTF) (fig. 2). The PFTF is a pod carried under an F-15B aircraft to provide the capability to test large scale airbreathing propulsion engines. In D-REX, a simple flowpath and systems were planned to be used to obtain ducted rocket flight data, gain operational experience, and demonstrate hot fire capability (ref. 3). The D-REX flight hardware was developed in-house at NASA Dryden by approximately 10 participants.

USAGE

This section describes the features and usage of the eSE. Like other software driven by a graphical user interface (GUI), it is intended to be usable without the need for a detailed manual.

Access Control

Access to the system is controlled through the use of a small access file that is distributed to all the users. When the file is opened, the user name and password is requested. Both fields can be left blank for read-only access. The database is opened at one of the four access levels assigned to the user: administrator, project, user, and public. Access control is currently provided, but more rigorous security measures, such as encryption, are not.

Administrator

The administrator access level allows complete control of the database, including programming and defining layouts. Access at this level requires an additional password.

Project

The project access level is intended for use by project-level personnel such as the project manager, chief engineer, operations engineer, systems safety, and systems engineering. It allows nearly complete control of the database contents, except in certain cases to preserve integrity. For example, records that have been signed off cannot be deleted.

User

The user access level is assigned to the majority of users. It allows the viewing and editing of the database contents, except when a lockout is imposed under certain conditions. For example, records that have been signed off cannot be modified.

Public

The public access level allows read-only access without a password. It can be disabled if desired.

Document Library

The document library contains the product data for each project in various formats. The interface is like other typical GUI file managers but contains additional features for product data management. For example, metadata, such as author and revisions, are stored and can be searched on. Revision histories are maintained. Electronic signatures can be used to approve documents. Documents can be checked out for editing, and only the users who check the documents out can check them back in. This way, multiple users are not inadvertently editing the same document. Figure 3 shows an example of a document library.

Documents can be accessed from other modules by means of links. A document must be filed in the document library before it can be attached to a record elsewhere in the database.

The database actually manages only the metadata of the documents and provides links to the document files through uniform resource locators (URLs). An advantage of this approach is that a failure or malfunction of the database cannot compromise the document files. Documents are uploaded to the server by simply copying the file to the server directory.

Configuration Control

Tracking the configuration, discrepancies, and tests of an entire flight vehicle is a complex task. At NASA Dryden, a configuration control board (CCB) manages this process. The configuration control module, however, was not used in the pilot project. Processes and applicable forms, such as configuration control requests (CCRs), discrepancy reports (DRs), and system test reports (STRs) are implemented in the eSE. Figure 4 shows an example of the CCB DR form. The CCR and STR forms have similar formats. Links allow easy navigation between related forms. A history of actions is automatically compiled on a form. Supporting documents can be electronically attached. Summary tables can be automatically generated. Interlocks help prevent unauthorized alteration of data depending on the phase in the process. Signature blocks are locked out depending on access level. A list of configuration items (CIs) is maintained.

The CCB automation process begins with an online user request for CCB actions. The CCB agenda is automatically generated from the requests (figure 5 provides an example). At the CCB meeting, these requests are reviewed and acted upon in real time. Actions are recorded in the CCB action field, and the date field is filled in. The CCB meeting minutes are automatically generated from the data that was entered.

Hazard Management

Managing hazards is a significant effort in flight projects. At NASA Dryden, standard hazard report (HR) forms and processes are implemented. Figure 6 shows an example of an HR form. As with the configuration control forms, links, form histories, attachments, summary tables, interlocks, and electronic signatures are implemented. An HR can be automatically generated using data from hazard analyses. To support hazard analyses, three techniques are incorporated (ref. 4): preliminary hazard analysis (PHA), failure modes and effects analysis (FMEA), and fault tree analysis (FTA).

Preliminary Hazard Analysis (PHA)

A PHA is a structured way to explore potential hazards early in the program. It is implemented as a simple table.

Failure Modes and Effects Analysis (FMEA)

This technique is a rigorous analysis of potential single point failures. It also is implemented as a table but has links to the component database to aid in data entry and help ensure consistency. To help interpret the large volume of data, the list can be sorted by component, hazard rating, or mission phase by simply clicking on the header.

Fault Tree Analysis (FTA)

This analysis explores potential causes and mitigations for an undesirable top level event. A simple fault tree can be constructed and manipulated using a GUI, although the format is horizontal because of program limitations. Probabilities of events can be calculated. In FTA, cut-sets are used to evaluate potential causes, but this feature has not yet been implemented.

Hardware Database

Tracking flight hardware and its development involves organizing and managing large quantities of data. As shown in figure 7, this module consists of five databases linked together: component types, unit components, vehicle components, subsystems, and instrumentation. These five linked databases allow the interconnection of relevant information.

Component Types

Component types are the particular hardware designs. Data associated with component types include flight qualification requirements, flight qualification approach, drawings, documents, price, heritage, and design life. Qualification matrices can be automatically generated from the data provided. Links are provided to vehicle components of this type and inventory of individual components. Fields can easily be added to meet specific project needs. For example, in the pilot project, component materials were tracked to help ensure compatibility with propellants. Figure 8 shows an example of a component type data sheet.

Unit Components

Unit components are the actual physical pieces of hardware. Data associated with unit components include serial number, acceptance testing, usage and cycle history, anomalous events, and associated documentation. Links are provided to corresponding component types and vehicle components. The official records typically are kept in the aircraft workbook, but an electronic database expands on that information and allows online access.

Vehicle Components

Vehicle components are the designations given to parts in the vehicle. For each vehicle component, a component type is associated with it, and a unit component can be installed in it. This information must be configuration controlled and can be used to support a physical configuration audit of the vehicle. Links are provided to corresponding component types and unit components. Official records for parts removals and installations also are kept in the aircraft workbook.

Subsystems

Subsystems organize the physical project elements into logical sections. These sections should include, in addition to vehicle subsystems, other essentials such as ground service equipment and the test range. Interfaces between subsystems can be defined and associated with interface control documents (ICDs).

Instrumentation

Instrumentation is the table of data related to instrumentation parameters and traditionally is maintained by the instrumentation engineer. The data can be edited and viewed online, with links to corresponding vehicle components, component types, and unit components.

Requirements

Project requirements traditionally are managed using documents and spreadsheets. This management method was considered adequate for D-REX, which was a relatively small in-house project. For more complex projects, however, a data-centric approach may provide significant benefits by reducing repetitive tasks and inconsistency errors, especially for changing, tracing, and verifying requirements. Excellent enterprise-level tools exist for these functions, but they may not be available or affordable in some cases.

In this module, the requirements outline can be constructed and manipulated with a GUI. More than one requirements set can be defined. Requirements between various sets can be linked, a task that is very tedious to perform manually. Verification requirements matrices and requirements documents can be automatically generated from the database. Figure 9 shows an example of a requirements document generated from the database. For tracking purposes, each requirement is assigned a unique five-digit identification number that never changes, regardless of its line item number in the requirements document.

Action Items

Action items commonly are used to track project activities. Through the use of this module, actions can be requested, viewed, and responded to online in real time. The status of each item (open, closed, late) is automatically tracked. Electronic signatures are used to submit and accept closing actions. A "nag" button can be used to remind action recipients (through E-mail) of overdue items or any updates requiring attention. This module can be used to support various project reviews and help ensure that request for information (RFI) items are tracked, addressed, and closed. Figure 10 shows an example of an action items list.

Team Information

Most projects maintain a team roster, organization chart, and project-specific training records. This module is not intended to replace actual directory services or personnel records. Training class rosters and each individual's class attendance can be viewed. One or all personnel can be contacted by E-mail at the push of a button. A simple organizational chart can be generated in a horizontal outline format. This module also is used to support the access control and electronic signature features of the software.

Metrics

Tracking technical performance metrics is a common practice for measuring the status and progress of a project. In this module, current best estimates (CBEs), allowable limits, and margins of metrics can be tracked. Time histories of metrics are presented both graphically in a plot and in tabular form. Data can be imported and exported in common text formats. The plot is simply an embedded object from a spreadsheet and graphing program, thus the format can be freely changed to the extent that the graphing program allows. Figure 11 shows an example of a technical performance metric.

Data Import and Export

Features are implemented for users to export several standard reports to tabulated text files. In addition, the administrator can import and export any combination of data in a variety of formats. The platform database program supports the importation of several text and spreadsheet formats, and the exportation of text, spreadsheet, and hypertext markup language (HTML) formats.

DISCUSSION

The benefits of an online systems engineering tool, the eSE, have been demonstrated. The eSE facilitated in-house development of the D-REX project. Part of the challenge being addressed is to organize and provide easy access to a large volume of information. Ideas for improvements and features suggested by project members have been implemented. “Bugs” and other issues discovered by users have been corrected.

The eSE is fairly stable and usable in its present form and could be made available to other projects. It can also be easily modified for specific project needs. Currently eSE is probably most suitable for in-house projects. The database administrator should be familiar with the platform database but does not need to be a computer professional.

Some additional features and improvements are suggested. For example, E-mail notification could be provided for certain events. The system could be easily interfaced with other tools at the center that use the same platform database, as appropriate. Other programs could be used to access the database by means of standard interfaces.

The benefits of complete integration across the project have been demonstrated; however, if a system of this type is to be more widely deployed, it probably would be separated into several process-centric products, corresponding to an existing organizational structure. These products may include configuration control, safety, and projects (documents, actions, metrics, requirements, and hardware). Notionally, the configuration control and safety modules would have a center-wide server, whereas each project would have its own project module server that could be customized. This approach would simplify systems maintenance, facilitate cross-project data sharing, and allow customization in project-specific areas. In this case, eSE should be migrated to the newly released version of the platform database software. The new version has significant new features, such as an improved Web server, built-in user identification and password security, and extensive import and export capabilities. The database would then reside on a server and could be accessed from any workstation through the use of a Web browser.

CONCLUDING REMARKS

An online systems engineering tool for flight research projects was developed through the use of a workgroup database. The principal observations are as follows:

- The features implemented include document library, configuration control, hazard analysis, hardware database, requirements management, action item tracking, project team data, and technical performance metrics. Existing processes and forms are implemented, rather than inventing or changing processes to fit the tool.
- The life cycle cost of this type of implementation is approximately one-fifth that of enterprise-level systems.
- By using a workgroup database platform, personnel most directly involved in the project can develop, modify, and maintain the system.
- The system has been demonstrated and developed on a pilot project, the F-15B Propulsion Flight Test Fixture Ducted Rocket Experiment.
- The system could be made available to other projects.
- An integrated project tool set offers numerous advantages. If the system is to be widely deployed, however, it probably would be separated into several process-centric products and migrated to the newest version of the platform database.

REFERENCES

1. Shishko, Robert, *NASA Systems Engineering Handbook*, NASA SP-6105, 1995.

2. Moyer, Chris, and Bob Bowers, *Advanced FileMaker Pro 5.5 Techniques for Developers*, Wordware Publishing, Inc., Plano, Texas, 2002.

3. Corda, Stephen, M. Jake Vachon, Nathan Palumbo, Corey Diebler, Ting Tseng, Anthony Ginn, and David Richwine, *The F-15 Propulsion Flight Test Fixture: A New Flight Facility For Propulsion Research*, NASA TM-2001-210395, 2001.

4. Goldberg, B. E., K. Everhart, R. Stevens, N. Babbitt, III, P. Clemens, and L. Stout, *System Engineering “Toolbox” for Design-Oriented Engineers*, NASA RP-1358, 1994.

FIGURES

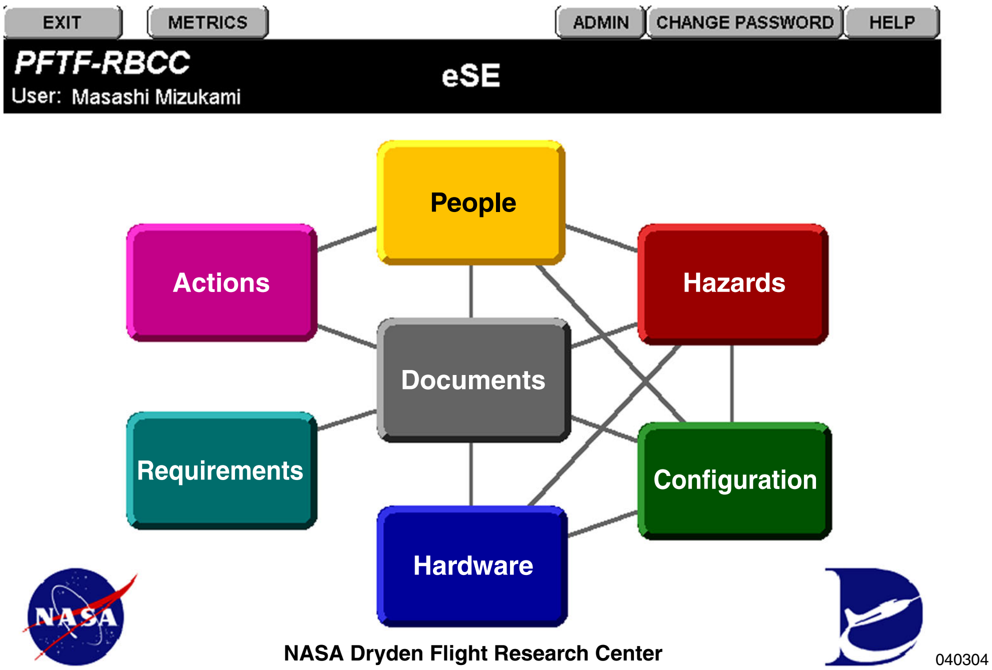

Figure 1. Overall setup of the Electronic Systems Engineering (eSE) modules.

EC01-0324-3

Figure 2. F-15B aircraft in flight with Propulsion Flight Test Fixture.

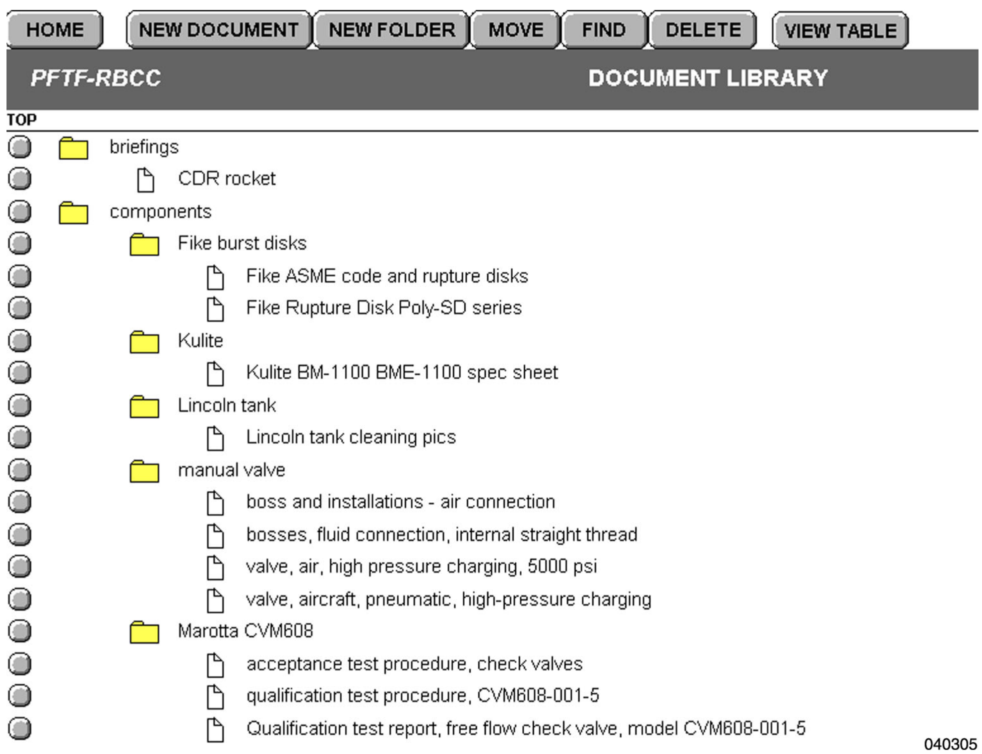

Figure 3. Document library example.

National Aeronautics and
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Discrepancy Report (DR)

Software/Hardware Control Management

Project PFTF-RBCC	Originator/Org: Banks, George	Site: airplane	Date & Time Of Dkc.: 1/2/1901		Dr No. 1
☒ VEHICLE ☐ CONTROL ROOM ☐ SIMULATION ☐ OTHER:	A/C Facility 844	A/C S/N:	Flt No Or Test No	Criticallty:	Assigned To:
	Part Name:	Part No.:	Serial No.:	CI No.: (system)	Inl. Ccb Review Date:
	TITLE: mouse in aircraft				

Decrepancy: mouse found in experimental aircraft	
Signature: tom	Date: 6/18/2003
Disposition: access panel open overnight	
Signature: tom	Date: 6/18/2003
Required Fix: (work-around) keep cat	
Signature: tom	Date: 6/18/2003
Closing Action: cat obtained and trained	Work Order: PCN NO.: CCR NO.: 1 CLOSED STR NO.: 123

Tested By: brad	Date: 6/18/2003	Witnessed By: brandon	Date: 6/18/2003
CCB official Me	Date: 6/18/2003	CCB Official: Kevin Long	Date: 10/15/2003

DFRC 9 (08/01)

COMPUTER DATABASE. PRINTED DOCUMENTS ARE FOR REFERENCE ONLY

Attachment (tile name): VIEW

Cockpit Panel Rev. 1.0.ppt

040306

Figure 4. Configuration control board (CCB) discrepancy report (DR) form example.

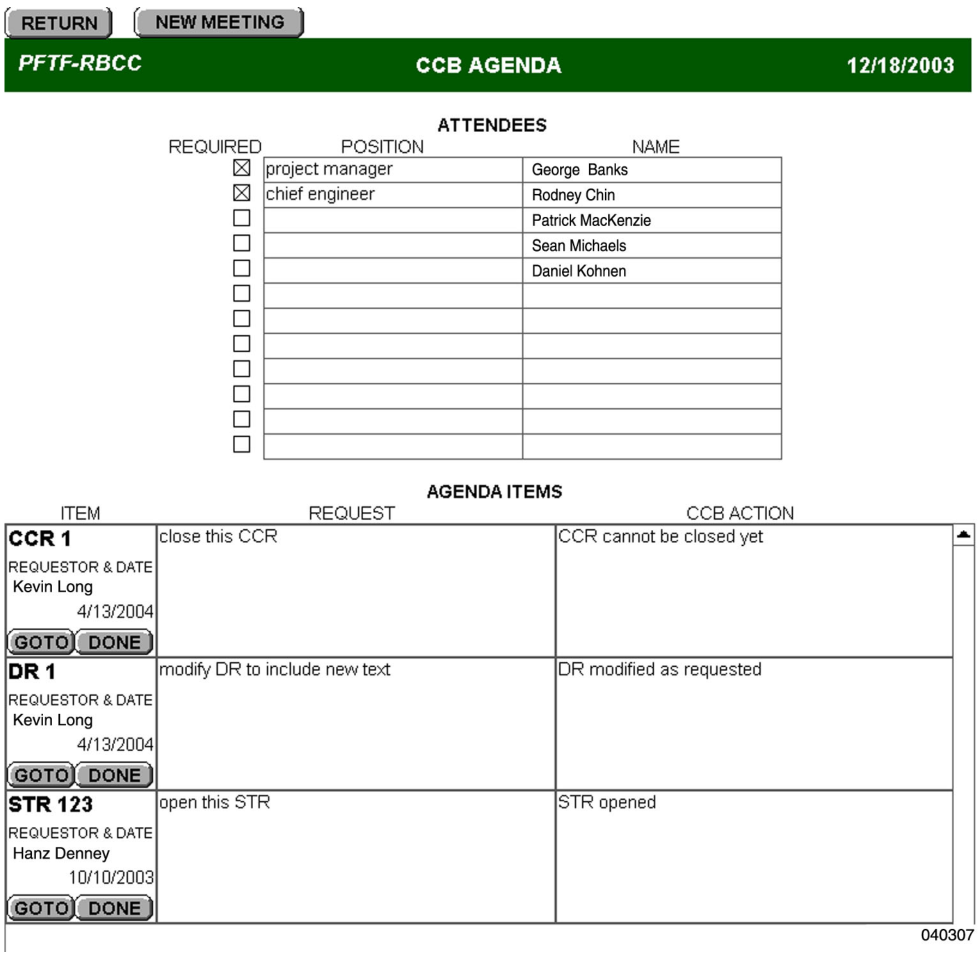

Figure 5. Configuration control board (CCB) agenda example.

National Aeronautics and
Space Administration

Dryden Flight Research Center

HAZARD REPORT (HR)

PROJECT	ORIGINATOR/ORG.:	TITLE	SITE	DATE	HR NO.
PFTF-RBCC	Chin, Rodney / RA	Loss of Control	DFRC	12/5/2002	DRex 05

Information source:	Location:	A/C FACILITY	A/C S/N:	CATEGORY/PROB.:	ASSIGNED TO:
☒ DESIGN REVIEW ☒ HAZARD ANALYSIS ☐ FIELD REPORT ☐ TEST ☐ DISREPANCY RPT	☐ SAFETY STUDY ☒ VEHICLE ☐ CONTROL ROOM ☐ SIMULATION ☐ OTHER	F-15B	836	1E	Chin, Rodney

SYSTEM NAME:	CI NO.: *(SYSTEM)*	RELATED DR'S:
PFTF / DRex		

HAZARD ANALYSIS OR SAFETY STUDY NAME:
Preliminary Hazard Analysis

HAZARD DESCRIPTION AND JUSTIFICATION FOR CATEGORY / PROBILITY RATING:
Loss of control due to the experiment could result in loss of aircraft and/or life (**Cat 1**). The PFTF / DRex configuration is predicted to cause a small reduction in open-loop directional stability and dihedral effect compared to a baseline F-15B. An extreme misprediction of the experiment configuration S&C characteristics would be required for the experiment to the cause the aircraft to go out of control during a CAS failure. This is considered improbable (**Prob F**).

SIG.: DATE:

CAUSE
1) Yaw /Roll CAS failure while at high supersonic Mach numbers and an extreme misprediction of the reduced open-loop $Cn\beta$ and $Cl\beta$ due to the presence of the PFTF / DRex experiment.
2) Rocket thrust

SIG.: DATE:

HAZARD EFFECTS:
1) Structural damage or loss of F-15B or chase aircraft and possible resulting loss of life
2) Loss of life at ground impact.

SIG.: DATE:

CONTROL BOARD ACTION

☐ OPEN
☐ ACCEPTED *(TO RISKLIST)*

RECOMMENDED ACTION

PROJECT MANAGER: DATE: PROJECT MANAGER: DATE:

HAZARD RISK REDUCTION ACTION

Mitigation of this hazard by Design and Previous Flight Test Experience:
1) Flight tests of the similar sized and shaped AFTF and PFTF Cone Drag Experiments with the CAS off have shown acceptable handling qualities with the CAS off at speeds up to Mach 1.8 and no pilot concerns at speeds greater than 1.8.

2) It has been shown in the sim that the maximum expected DRex experiment thrust of 1100 lb will not result in loss of control since it is in the axial direction nor will it cause any handling qualities degradation (sim study still to be

SIG.: DATE:

CLOSING ACTIONS

PROJECT MANAGER:
DATE:

PROJECT PILOT:
DATE:

HR FORM (1/96)

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ATTACHMENT (FILENAME):

☐ DISAPPROVE

040308

Figure 6. Hazard report (HR) example.

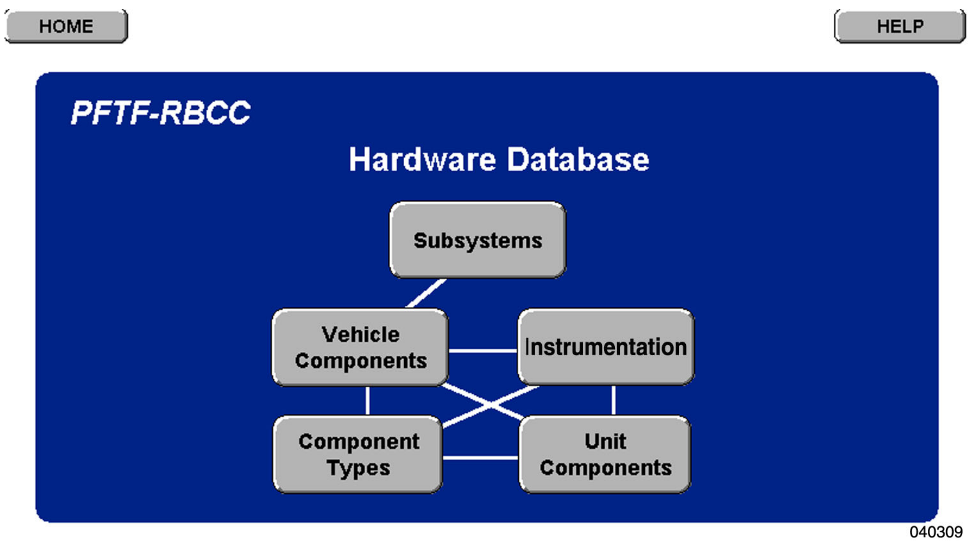
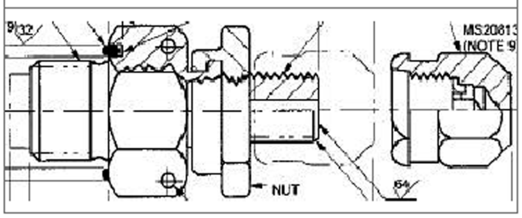


Figure 7. Hardware database.

PFTF-RBCC	COMPONENT TYPE DATA	4/9/2004

		VEHICLE P/N	INVENTORY S/N
MFR.		MV-FUP-02 MV-OXP-02	001 002 003 004 005 006
MODEL	**M6164-2**		
MFR P/N	**NSN 4820005356483**		
DESCRIP.	**manual valve**		
			or QTY:

	REQUIREMENT	QUALIFICATION	STATUS
ALTITUDE			n/a
THERMAL	-65F to +160F cold temps during blowdown	test per requirement	TBD
VIBRATION	DCP-O-018 random vibe curve A (8.0 Grms), 3 axes, 20 min/axis, protoflight	test per requirement	TBD
SHOCK			n/a
EMC			n/a
PRESSURE / LEAK	burst test 7500 psi external leak bubble tight at 3000 psi internal leak ?? sccs at 3000 psi	bubble tight (by immersion) at 5000 psi burst to 12500 psi	ok
LIFE	??? open-close cycles	100 open-close cycles to 55+/- in-lb torque (good for 25 cycles?) longer life based on extensive heritage?	TBD
FUNCTIONAL		flow at least 80 lpm gas at 5000 psi audible pressure warning over 50 psi	n/a
OTHER			n/a
ACCEPTANCE	proof test 4500 psi		

DOCUMENTS
MIL-PRF-6164F.pdf
MS33649.PDF
MS33651.PDF

HERITAGE

REMARKS
consider M6164-12 for thermal qual and higher cycle life.

MASS (lbm)

	max	units
LIFE		

☐ LIFE LIMITED

PRICE $ 70
Vendor

PRESSURES (psi)

oper	
MEOP	5000
proof	
burst	

FITTINGS

type	size
see dwg	

WORKING FLUIDS
GN2

WETTED MAT'LS
MIL-G-4343
MIL-H-6083
MIL-P-83461/1
metal?

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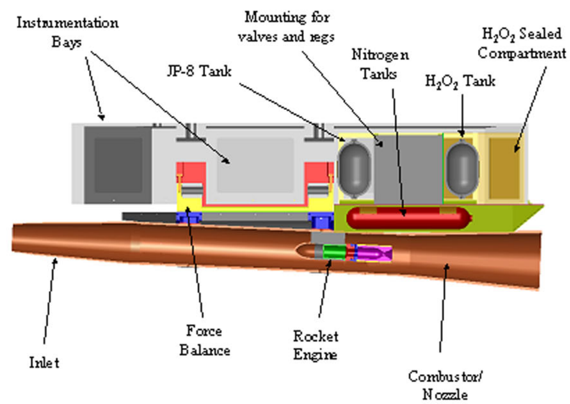
Figure 8. Component type data example.

PFTF-RBCC **4/13/2004**

Requirements for propulsion subsystem

1 fuel system

The fuel system will feed JP-7 to the engine



1.1 fuel system performance

The fuel system shall deliver 0.5 lbm/sec fuel at 500 psi at the engine interface. The test duration shall be 10 seconds, requiring a useful fuel load of 5 lbm

2 oxidizer system

The oxidizer system will feed 90% H2O2 to the engine

2.1 oxidizer material compatibility

Materials used in the oxidizer system shall be class I or II compatible with H2O2

2.2 oxidizer system performance

The oxidizer system shall deliver 0.5 lbm/sec of oxidizer at 500 psi at the engine interface. The test duration shall be 10 seconds, requiring a useful fuel load of 5 lbm

3 rocket engine

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Figure 9. Requirements document example.

HOME EXPORT

PFTF-RBCC **ACTIONS** **4/9/2004**

ID	TITLE	REQUESTOR	ASSIGNEE	DATE REQUEST (event)	DATE DUE	DATE CLOSE	STATUS
30	ask Prentex	Long, Kevin	MacKenzie, Patrick			12/18/2003	CLOSED
31	ask Lincoln Composites	Long, Kevin	MacKenzie, Patrick	6/26/2003			OPEN
32	ask manual valve vendor or user	Long, Kevin	Anderson, Greg	6/26/2003		10/16/2003	CLOSED
33	instrument quals	Long, Kevin	Michaels, Sean	6/26/2003		1/13/2004	CLOSED
34	write ORD	MacKenzie, Patrick	MacKenzie, Patrick	7/1/2003			OPEN
35	write requirements doc	Anderson, Greg	Long, Kevin	7/1/2003			PENDING
36	conversation with GK	MacKenzie, Patrick	MacKenzie, Patrick	6/26/2003		6/26/2003	CLOSED
37	CoDR RFAs Mizukami	Long, Kevin	MacKenzie, Patrick	3/5/2003 CoDR		4/1/2003	CLOSED
38	clean tanks and valves	MacKenzie, Patrick	Long, Kevin	8/19/2003		10/1/2003	CLOSED
40	component vibe tests	Long, Kevin	Kohnen, Daniel	10/14/2003	2/15/2004		OPEN

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Figure 10. Action items list example.

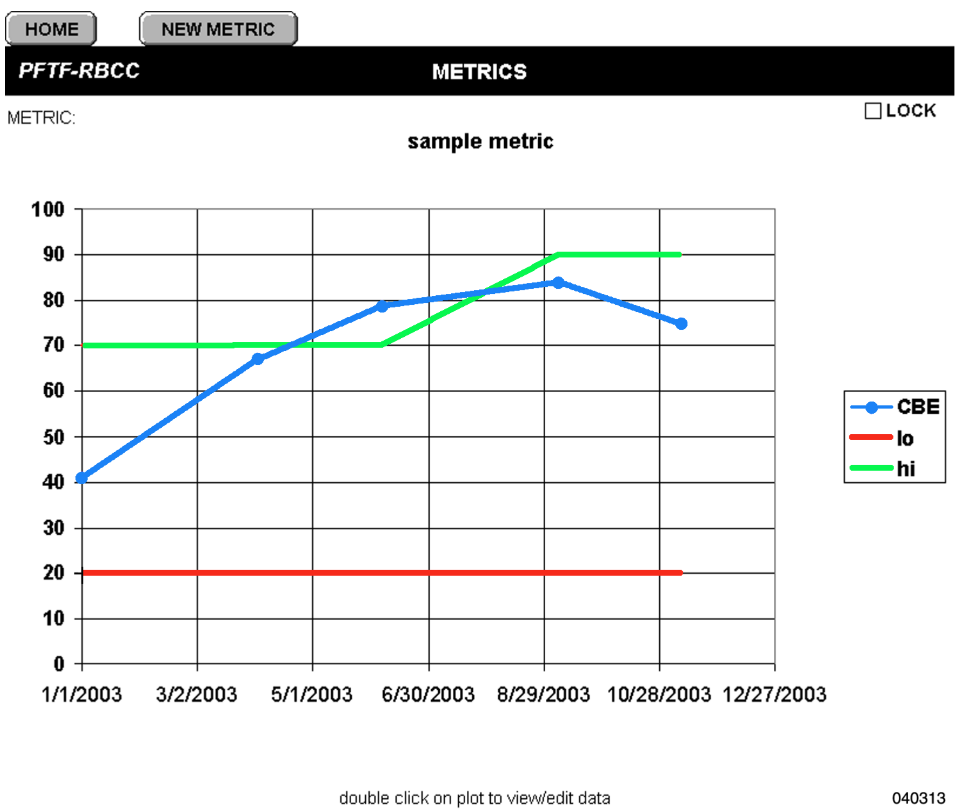

Figure 11. Technical performance metric example.

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14. ABSTRACT

An online systems engineering tool for flight research projects has been developed through the use of a workgroup database. Capabilities are implemented for typical flight research systems engineering needs in document library, configuration control, hazard analysis, hardware database, requirements management, action item tracking, project team information, and technical performance metrics. Repetitive tasks are automated to reduce workload and errors. Current data and documents are instantly available online and can be worked on collaboratively. Existing forms and conventional processes are used, rather than inventing or changing processes to fit the tool. An integrated tool set offers advantages by automatically cross-referencing data, minimizing redundant data entry, and reducing the number of programs that must be learned. With a simplified approach, significant improvements are attained over existing capabilities for minimal cost. By using a workgroup-level database platform, personnel most directly involved in the project can develop, modify, and maintain the system, thereby saving time and money. As a pilot project, the system has been used to support an in-house flight experiment. Options are proposed for developing and deploying this type of tool on a more extensive basis.

15. SUBJECT TERMS

Computer database, Configuration control, Flight testing, Product data management, Systems engineering

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